Renewable and Sustainable Energy Reviews 15 (2011) 4579–4585

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Energy market reforms in Turkey and their impact on innovation and R&D expenditures

Selahattin Murat Sirin*,[1]

Energy Market Regulatory Authority, Muhsin Yazicioglu Cad. No:51/C, 06530 Yuzuncuyil/Ankara, Turkey

A R T I C L E I N F O

Article history:
Received 11 March 2011
Accepted 5 July 2011
Available online 15 September 2011

Keywords:
Innovation
R&D
Energy market reforms
Turkey

A B S T R A C T

Energy sector is encountering serious problems which can be solved by technological innovations and increasing R&D expenditures. On the other hand, energy market reforms notably the establishment of competitive electricity and natural gas markets have resulted in a decrease of government energy R&D expenditures in most countries. Furthermore, there are rising concerns that private energy R&D expenditures are also declining as a result of energy market reforms, and companies are choosing customer-oriented innovations which may jeopardize the deployment of sustainable and renewable energy technologies. Turkey initiated energy market reforms in 2001, and has been trying to establish competitive electricity and natural gas markets since then. A survey of electricity and natural gas transmission and distribution companies in Turkey showed that nearly all of these companies have refrained R&D expenditures and have made organizational innovations mostly. Moreover, government energy R&D expenditures are very low compared to developed countries and enterprises are still trying to adapt to new market conditions. Nonetheless, energy market reforms may have positive effects on R&D expenditures and innovations as Turkey completes privatization of distribution companies, eliminates uncertainties in electricity and natural gas markets, and take measures to increase collaboration among enterprises, universities and government agencies.

Contents

1. Introduction

Innovation is the engine of economic growth, wealth creation and social well-being in modern economies. In addition, new technologies and new innovations are required to overcome the major problems in energy sector such as environmental degradation and air pollution, supply disruptions and increasing energy costs. On the other hand, innovation and R&D expenditures have significant differences from other investments that create market failure and hinder allocation of enough resources for innovation and R&D in competitive markets.

In addition to problems intrinsic to innovation and R&D expenditures, there has been growing concern about adverse effects of energy market reforms on innovation and R&D expenditures.

* Tel.: +90 312 201 44 29; fax: +90 312 201 44 00.
E-mail addresses: msirin@epdk.gov.tr, smsirin@yahoo.com

[1] The views expressed here are those of the author and do not necessarily represent EMRA.

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doi:10.1016/j.rser.2011.07.093

Energy market reforms namely restructuring, liberalization and deregulation were initiated in the early 1990s to increase labor productivity, to promote innovation and use of latest technology and to increase service quality. Although innovative activities of enterprises have increased after energy market reforms, government energy R&D expenditures have declined in many countries, and there have been evidence that private sector has been refraining energy R&D expenditures recently. Besides low energy prices during 1990s and the annulment of nuclear power plant projects in developed countries, energy market reforms are considered to have adverse impact on government and private R&D expenditures.

Turkey has initiated its energy market reforms in 2001, and has been spending efforts to establish competitive and liberalized electricity and natural gas markets since then. On the other hand, the impact of energy market reforms on energy R&D expenditures and innovation in Turkey has not been evaluated thoroughly. Therefore, this article aims to assess the impact of energy market reforms on R&D expenditures and innovations made by electricity and natural gas transmission and distribution companies.

In Section 2, the literature on the impact of energy market reforms on innovation and R&D expenditures will be presented. Innovative activities and R&D expenditures and the general problems that hamper innovative activities and R&D expenditures in Turkey will be summarized in Section 3. In Section 4, innovations and R&D expenditures of electricity and natural gas transmission and distribution companies will be discussed on the basis of obtained data and evidences through interviews with managers, firms' activity reports and official websites, and news published in the newspapers or magazines. Section 5 concludes the article and summarizes the findings.

2. Energy market reforms and innovation and R&D

Innovation is the key to economic growth and wealth creation in modern economies. Oslo Manual defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" [1]. Although this definition is very comprehensive, it can be deduced that innovation is a new or significantly improved product, process or method to the firm, and it must be implemented. Oslo Manual also defines four main types of innovation that are related with product, process, marketing and organization.

Similar to innovation, research and experimental development (R&D) plays an important role in technological development. Frascati Manual defines R&D as a "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" [2]. There are three types of R&D; basic research which involves experimental or theoretical work to acquire new knowledge about observable facts, applied research which involves work carried to acquire new knowledge for a specific aim, and experimental development which involves creation of new or mostly improved products, processes or systems. While basic research is only carried out by government agencies or universities and has no commercial purpose, applied research and experimental development are carried out by government and private sector and have commercial purpose.

Innovation and R&D expenditures have some significant differences from other investments, and these differences hinder allocation of enough sources for innovation and R&D in competitive markets. First of all, innovation and R&D have some characteristics of public goods such as low excludability, low rivalry and there are positive externalities in innovation, and all these lead to free-rider problem and create market failure [3]. Secondly, innovation and R&D include costly processes, require high initial investments, and scale economies are essential to reduce their costs. Finally, there are technological, market and trade uncertainties which increase risks for firms and adversely affect innovative activities and R&D. Therefore, government intervention (either direct government funding or creating incentives for private funding, faciliating and strengthening links among stakeholders, providing competition in markets and removing administrative barriers) is required to allocate enough resources to innovation and R&D in competitive markets [4,5].

Energy supply security and environmental degradation have been attending more focus since the 1970s when oil crises hit global economy and the sustainability of energy consumption patterns were began to be questioned. As a result, innovation and technological improvements/developments are being presented as the key solution to secure energy supply, to decrease adverse environmental effects of energy extraction and consumption, and to alleviate of social concerns. On the other hand, innovations and technological developments encounter more difficulties in energy sector notably in electricity and natural gas sector than other sectors. Electricity sector and natural gas sector require significant infrastructure investments and have large sunk costs, and most equipments are designed to operate for long years. Moreover, these sectors include both competitive and natural monopolistic activities, interdependencies among actors are higher than other sectors, and actors have comply with standards and technical requirements to assure functioning of the system effectively and safely [6]. Therefore, these sectors are more resistant to change, and incumbents in electricity and natural gas sector mostly prefer incremental innovations that comply with the infrastructure and do not compromise the functioning of the system [6].

In addition, energy sector has encountered major transformation since the early 1990s in many countries that affect innovation and R&D patterns, namely restructuring, liberalization and deregulation which aim to increase labor productivity and efficiency, to promote innovation and use of latest technology and to increase service quality [7,8]. Once considered as natural monopolies, vertically integrated public utilities in electricity and natural gas sector were restructured, transmission and distribution were unbundled from generation and supply, and competition was introduced in competitive parts. Moreover, most of the state-owned assets were privatized as a part of restructuring in many countries. As a result of these reforms, it is expected that firms will choose cost-efficient technologies which become profitable in short-term and make innovations to offer competitive prices and high quality services to consumers and to gain competitive advantages over other firms in competitive energy markets which in result stimulate innovation and R&D.

On the other hand, energy market reforms have altered the motivation for R&D expenditures which are essential for technological progress and innovation [9,10]. Utilities could pass R&D costs to customers in regulated markets which provide a non-risky environment for investments and guaranteed returns for investors. In contrast, R&D expenditures will no longer be oriented by public concerns or government choices, and firms will determine their R&D budgets according to profit concerns in competitive energy markets [11,12]. Furthermore, risks and uncertainties in competitive markets may depress innovative activities and R&D expenditures, and firms may engage in less-risky and less-costly innovations or R&D activities that will result in a product or a service in short term [9,10,13]. In addition, public utilities may also shift their R&D expenditures from basic research and applied research to experimental development, and their R&D expenditures may decline as a result of increasing competition or privatization of public utilities [11,14,15]. Some studies

examining the effects of energy market reforms on innovation and R&D expenditures stress that energy R&D expenditures have decreased considerably in real terms in major economies since the beginning 1990s, and they attribute this decline mainly to restructuring [4,11,16,17]. Moreover, there have been suggestions that energy equipment manufacturers have also reduced their R&D expenditures with the transition process [4]. On the other hand, some authors point that R&D expenditures in regulated markets were mainly determined by political and social concerns which led to a waste of resources for useless activities, and the decline in R&D expenditures may not hamper technological innovation [4,13]. In competitive markets, firms are expected to focus on customer-oriented projects and to allocate funds to projects where the outcome will be quicker. In addition, some studies attribute the decline in R&D expenditures to the transition process, and it is claimed that uncertainties regarding liberalization and deregulation process adversely affect both public and private sector investment decisions which includes R&D expenditures [10,13,15].

Overall, there are rising concerns that energy market reforms have adversely affected both the quantity and the course of energy R&D expenditures and innovations which are essential for clean and sustainable energy technologies, and a significant market failure may have emerged as a result of these reforms. On the other hand, similar problems are also experienced in other sectors, and increasing competition in global markets and rising risks costs of innovation force firms to curtail R&D expenditures, to speed up and to internationalize their innovative activities [18–20]. Moreover, transnationalization of domestic energy utilities via mergers and acquisitions have impacts on innovative activities and R&D expenditures, and have forced firms to rearrange their R&D and innovation priorities [17]. In addition, electricity and natural gas prices are significant determinants of energy R&D expenditures, and energy market reforms mostly coincided with low energy prices in the 1990s [20]. Therefore, recent increases in energy prices may have positive effects on energy R&D expenditures and innovations in the coming years.

3. R&D expenditures and innovation in Turkey

Turkey's science and technology policy making dates back to early 1960s; however, Turkey's innovation and technology profile still lags behind many developed and developing countries. Until 2001, macroeconomic problems such as high inflation and high interest rates, political instabilities and severe economic crises hampered both government and private sector innovation and technology investments to a great extent. The major economic reforms initiated in 2001 and political stability in recent years led to a significant decline in inflation and interest rates, and created a conducive climate for investments. In addition, government initiated "Vision 2023" project that aims to stimulate private sector R&D expenditures, to increase cooperation among universities, enterprises and government bodies, to increase the share of innovating firms, and to promote the commercialization of the knowledge created. As a result of these developments, Turkey's innovation and technology profile has been improved recently; however, Turkey's gross domestic R&D expenditures (GERD) was only one third of European Union average in 2009, and it is still not well compared to other developing countries [21].

Similar to general R&D expenditures, Turkey's government and private energy R&D expenditures are very low compared to those of the developed countries. Turkey's total government energy R&D expenditures was 5.6 million USD (in 2009 prices and exchange rates) in 1992, and it only increased to 8 million USD in 2007. Meanwhile, total government energy R&D expenditures was 4181 million USD in USA, 1247 million USD in France and 589 million USD in Germany [22]. Since the beginning of 1990s, government energy R&D expenditures' share in GDP has declined in many developed countries as a result of low fossil fuel prices in the 1990s, annulment of nuclear power projects, restructuring of electricity and natural gas sectors and privatization of state-owned energy companies. However, this trend has been reversed recently due to increasing support for sustainable and renewable energy technologies. A similar trend has been witnessed in Turkey where government allocated more than 50% of its energy R&D expenditures to fossil fuel technologies until late 1990s. Since then, growing support for renewable energy technologies and establishment of International Center for Hydrogen Energy Technologies (ICHET) in 2004 in Turkey resulted in a major increase of renewable and hydrogen technologies' share in government energy R&D expenditures from 25% in 2000 to more than 50% in 2007 [22]. Besides government expenditures, private sector energy (electricity, gas and water supply) R&D expenditures are very low compared to developed countries, and their share was only 0.35% of total private R&D expenditures in 2007 [21].

Similar to R&D, innovation performance of Turkey has been low compared to EU. While 37% of firms in Turkey engaged in innovative activities and just one third of firms made technological innovations during 2006–2008, almost 50% of firms made innovations in EU [23,24]. In addition, there has been a slight decline in the share of firms that made technological innovations during 2004–2008 in all sectors in Turkey. On the other hand, the share of firms that made innovations in electricity, natural gas and water supply sector has declined from 27.5% to 17.8% during this period [23]. Considering the privatization of some public utilities after 2001 economic crisis and the restructuring of electricity and natural gas sectors, this significant decline may be assessed as a result of reforms in these sectors.

Turkey should take measures to increase its R&D expenditures and innovative activities in order to compete with other developing countries and to attract foreign direct investments. On the other hand, there are some major obstacles that hinder private R&D expenditures and innovations in Turkey. One of these major obstacles is related with costs and financing. Due to high risk premiums, obstacles in accessing capital and high initial costs, private firms are refraining from innovative activities [25]. Even tough government agencies provide support schemes such as grants and low interest loans, private sector is still encountering difficulties in accessing capital. The second major obstacle is the problems regarding the creation and commercialization of knowledge. The number of researchers per 1000 labor force in Turkey is very low compared to developed countries. Moreover, there are regulatory constraints that prevent researcher and expert transfer among universities, public sector and private sector. In addition, the linkages among these actors are weak, and there are problems in commercialization of knowledge created in universities and public research centers [26]. The third major obstacle is related with weak technical infrastructure, rigidities in labor and fiscal regulations, weak intellectual property rights protection and high share of informal economy which all limit skilled labor employment and adversely affect the technological intensity of products produced in Turkey [25]. Although recent economic and legal reforms aim to overcome these problems, more efforts are needed to increase Turkey's science and technology profile.

4. Energy market reforms in Turkey and impact of R&D expenditures and innovation

4.1. Electricity market reform in Turkey and R&D and innovation

Turkey has achieved a significant economic growth in the last two decades and has one of the highest electricity demand growth

rates among OECD countries. High economic growth accompanied with high urbanization resulted a dash for gas in the mid-90s, and natural gas has become the primary source for electricity generation. In 2008, a total of 198,418 GWh electricity was produced from natural gas (49.7%), coal (29%), hydro (16.7%), gas (49.6%), and other sources (4.4%) [27].

Until the mid-1980s, electricity generation, transmission and distribution were controlled by state-owned and vertically integrated Turkish Electricity Authority (TEK) which was founded in 1970. As a part of economic reforms initiated in the early 1980s and due to budgetary constraints, Turkey initiated Built-Operate-Transfer (BOT) and Transfer-of-Operating Rights (ToOR) regimes in 1984 to allow private participation in generation investments. In 1993, TEK was split into two state economic enterprises, Turkish Electricity Generation Transmission Co. (TEAS) which was responsible for the generation and transmission and Turkish Electricity Distribution Co. (TEDAS) which was responsible for the distribution of electricity and electricity services trade. Despite the restructuring of TEK and implementation of new regimes such as Built-Own-Operate (BOO), electricity sector was encountering serious problems such as insufficient investments, high electricity demand growth and high theft and loss rate, and government attempts to privatize TEAS and TEDAS were annulled by jurisdiction.

In line with economic reforms initiated after 2000/2001 economic crises and to fulfill European Union accession prerequisites, Electricity Market Law was enacted in 2001 with the aim to establish a competitive and liberalized electricity market. EML aims to establish a financially sound and transparent electricity market and to deliver sufficient, good quality, low cost and environment-friendly electricity to consumers in a competitive environment. In addition, TEAS was unbundled into three separate economic enterprises, namely Turkish Electricity Transmission Co. (TEIAS), Electricity Generation Co. (EUAS) and Turkish Electricity Contracting and Trading Co. (TETAS), and EML envisages the privatization of the all public entities except for TEIAS. Moreover, an independent regulatory authority – Energy Market Regulatory Authority (EMRA) was established and charged with effective functioning of the market [28].

4.1.1. Innovation and R&D in Electricity Transmission Companies

Under EML, the transmission activity in the market is performed by TEIAS which is transmission system operator and the market operator. TEIAS is responsible for the operating, repairing and maintaining the national transmission system and establishing an infrastructure suitable for a competitive environment to ensure the formation and sustainability of an efficient, stable and economical system in the market.

According to activity reports and financial tables of TEIAS, there were no R&D expenditures during 2001–2009 [29][2]. On the other hand, TEIAS initiated some R&D projects since 2003 when its research department was established. In 2006, TEIAS has initiated “National Power Quality Project” which aims to increase the quality of transmission system and enhance the system’s capacity to comply with universal standards. In this project, TEIAS has cooperated with a government agency (TUBITAK) and four universities (Hacettepe, METU, Dokuz Eylul, Yıldız Teknik). Nearly all of the project’s expenditures are compensated from TUBITAK’s budget, TEIAS compensated only a small part of these expenses which are not accounted in TEIAS’s R&D expenditures.

TEIAS has also participated in innovative activities and made some product/process, marketing and organizational innovations. Among these, opening of fiber optic infrastructure for commercial usage and enterprise resource planning project are the most significant innovations. The first one is related with marketing innovation and it is the first application of this kind in Turkey in which TEIAS has opened its fiber optic infrastructure for commercial usage and leased some of its fiber optic infrastructure for ten years. The second one was initiated to improve TEIAS’s organizational capacity and to increase efficiency within the enterprise, and it was completed in 2010.

4.1.2. Innovation and R&D in Electricity Distribution Companies

Under EML, the distribution activities are performed by TEDAS and private sector distribution companies in the distribution regions. The distribution companies are responsible for the construction, operation, enhancing, repair and maintenance of the new distribution facilities, keeping a database of updated records on consumers in their regions, and providing retail sale to consumers who are unable to purchase electricity from another supplier. Before the enactment of EML, there was only one private distribution company (Kayseri ve Civarı Elektrik TAŞ) which was established and given privileged operation rights in 1926. As a part of the economic reforms initiated in 2001 and due to EML provisions, Turkey’s distribution network was divided into 21 regions (including Kayseri), and distribution companies were established in these regions. EML envisages privatization of all distribution companies, and privatization of 12 distribution companies were completed.

Among the six distribution companies interviewed, none of the distribution companies has performed R&D expenditures. On the other hand, all six distribution companies have made innovations which are shown in Table 1. Although the number of innovations differ among companies, all companies have made at least one innovation. The first type of innovation is related with product and process innovations. Distribution companies have initiated on-line customer services which enabled customer to reach information about their bills, consumption figures, etc. Moreover, some distribution companies started to inform customers via e-mails or cell phone messages, and to use new high-tech equipments for the network maintenance and repair. The second type of innovation is related with marketing and some distribution companies used new methods (such as mobile pay desks) for customer subscriptions and bill payments. The third type of innovation is related with organizational innovations. Among all the innovations, organizational innovations have been a priority for distribution companies and all distribution companies have made innovations to enhance their IT system and improve their technical infrastructure. The other organizational innovation is the establishment of intra-firm vocational training systems and use of new management methods to improve efficiency and effectiveness. In line with the use of new management methods, some distribution companies obtained international quality management system certificates such as ISO 9001.

Table 1
Innovations made by Electricity Distribution Companies.

Product/process innovations	-Online customer services -Use of new technologies
Marketing innovations	-New subscription and payment methods
Organizational innovations	-Improvement of IT systems and technical infrastructure -Use of new management methods -Acquisition of international quality management system certificates,

[2] R&D expenditures of transmission and distribution companies are retrieved from financial tables of those companies. According to Turkish accounting system, R&D expenditures are recorded in line with Frascati Manual.

Considering the R&D expenditures and innovations made by Electricity Transmission and Distribution Companies, it can be said that establishment of a competitive and liberalized electricity market resulted in major organizational innovations and some product/process and marketing innovations in Turkey as witnessed in other countries. On the other hand, none of these companies have made R&D expenditures. The major reason for this outcome can be explained as the uncompleted or newly completed privatizations. The officers of newly privatized companies stated that they are focusing on the organizational problems, therefore, they preferred innovations to overcome these problems. Moreover, they stated that they do not want to make unnecessary expenditures, and they may initiate or participate in R&D projects in the coming years.

4.2. Natural gas market reforms in Turkey and R&D and innovation

Turkey started to use natural gas for commercial purposes in the mid-70s after discovery of natural gas in the Marmara Region. In the following decades, deterioration of air quality in major cities, commissioning of gas-powered plants to cover increasing electricity demand and expansion of natural gas usage in major industries resulted in a significant increase in natural gas consumption, and Turkey had to sign natural gas imports agreements due to lack of domestic natural gas reserves. Following the developments in natural gas usage, Decree of Natural Gas Utilization No. 397 was enacted in 1990 and Petroleum Pipeline Corporation (BOTAS) was given monopoly rights on natural gas import, distribution, sales and pricing. In addition, natural gas distribution was started in six cities in the late 80s.

As a part of reforms initiated to fulfill European Union accession prerequisites, to overcome the problems in natural gas sector and to attract foreign investors in Turkish energy sector, Turkey enacted Natural Gas Market Law (NGML) No. 4646 in 2001 with the aim to establish a competitive and liberalized natural gas market. The NGML aims to form a financially sound, stable and transparent natural gas market to supply natural gas to consumers in a regular and environmentally sound manner at competitive prices [30]. BOTAS was restructured and its monopoly on gas import, transmission, sales and pricing was abolished, and EMRA is charged with effective functioning of the natural gas market. Under NGML, import, production, transmission, storage, wholesale, export and distribution of natural gas are defined as market activities, and legal entities has to obtain license from EMRA to undertake these activities.

4.2.1. Innovations and R&D expenditures in natural gas transmission

NGML defines transmission as the transportation of natural gas through a natural gas pipeline network other than distribution networks, or through Liquefied Natural Gas (LNG) vehicles and vessels. Contrary to electricity market, transmission is not defined as a monopolistic activity in NGML, and more than one firm may have transmission license. On the other hand, EMRA defined two types of transmission license: (1) Liquefied Natural Gas (LNG) transmission license, and (2) pipeline transmission license. As of January 2011, 17 firms obtained LNG transmission license and only BOTAS obtained pipeline transmission license.

Pipeline transmission licensee is responsible for the flow of natural gas and operation of the system, as well as performance of other necessary services. Furthermore, the transmission companies have to take any measure for safe, secured and effective gas transmission in a cost-effective way through the lines under their responsibility [30].

Considering the rights and duties of a transmission company, there are many oppurtunities for transmission companies to perform R&D expenditures and to make innovations. On the other hand, BOTAS has not performed any R&D expenditures since 2001. Although, there is no explanation why BOTAS has not performed any R&D expenditures in its activity reports, the uncompleted transition to a competitive and liberalized natural gas market and uncertainties regarding BOTAS's status may be considered as the major factors that prevented BOTAS to perform R&D expenditures.

Contrary to R&D, BOTAS has made some innovations and participated in innovative activities since the enactment of NMGL. According to BOTAS's activity reports, there have been three major innovations BOTAS has made. The first one is establishment of a new facility to fill LNG to vehicles in 2007. The main driver for this facility is the need for new means to supply natural gas. The other innovations are "BOTAŞ Entegre Yönetim Sistemi" and "BOTAŞ Bilgi Sistemleri Projesi". The first one was initiated in 2002, and it aims for better management, decreasing operation costs, increasing security conditions, and it includes acquisition international standard and quality certificates. The second one was initiated in 2005, and it aims to strengthen and improve the BOTAS's IT systems, technical infrastructure and to increase the efficiency and effectiveness of BOTAS's activities [31].

Considering BOTAS's R&D expenditures and innovations, natural gas market reform in Turkey has resulted in organizational innovations in the transmission company. BOTAS did not perform any R&D expenditures before 2001, and reforms has not resulted in any R&D expenditures since then. On the other hand, BOTAS has made some organizational innovations which aim for better management, increasing efficiency and decreasing costs.

4.2.2. Innovations and R&D expenditures in natural gas distribution

Prior to 2001, there were only seven natural gas distribution companies (two distribution companies were established in Istanbul), and two of them were owned by BOTAS while others were owned municipalities. NGML designed a new system for developing distribution network, and the system became a successful model for gasification of many cities in short time [32].

Distribution activity is defined as "the transfer of natural gas for purposes of delivery to clients through local gas pipeline network and its retailing" in NGML, and distribution companies carry out natural gas distribution and transportation activities through local gas pipeline system [30]. NGML envisages a competitive distribution tender which will be made by EMRA to give natural gas distribution licenses. In these tenders, biddings are evaluated on the basis of unit service and distribution charge (distribution margin) applicants offered, and the lowest bid wins the tender. Distribution margin includes costs regarding infrastructure investments and network operation costs, and distribution companies add distribution margin to the price of natural gas acquired from wholesale companies. Distribution margins for the new distribution companies are fixed for first eight years, then EMRA will determine distribution margins. The winner of the tender obtains its license for 30 years and has the right to operate distribution network. EMRA has made 53 tenders and gave 60 distribution licenses (including companies established before the enactment of 4646) until February 2011.

Distribution licensees have some rights and obligations which can be assessed under three headings: (1) Construction and operation of the network: distribution companies are responsible for the planning, designing, construction, expansion and operation of the distribution network. The licensee has to begin infrastructure investments within six months after its license acquisition, and it has to connect a certain area within 18 months. In the first five years, the licensee has to connect all the customers which are economically and technically feasible within its distribution area upon their requests. In addition, the licensee has to take all measures for the

Table 2
Innovations made by natural gas distribution companies.

Product/process innovations	-Online customer services
Marketing innovations	-Marketing campaigns -New subscription and payment methods (Mobile pay desks or subscription at door)
Organizational innovations	-Improvement of IT systems and technical infrastructure -Use of new management methods -Acquisition of international quality management system certificates -Customer education programs

effective and secure operation of network. (2) Retailing and billing: distribution company is responsible for the sale of natural gas, and metering and billing of the natural consumption, and they have to take measures regarding these activities. (3) Training and education: distribution company has to train its personel, local security and fire department personnel regarding security measures, and has to make emergency plans. In addition, it should inform customers about natural gas usage and security measures.

Among the distribution companies evaluated, only Istanbul Gas Distribution Industry and Trade Incorporated Company (IGDAS) which was established in 1986 and owned by Istanbul Municipality has performed R&D expenditures. Currently, four R&D projects are being carried out by IGDAS, and all these projects aim to enhance the functioning of the distribution network and improve the security of network. IGDAS cooperates with public agencies, universities and other enterprises in these projects. In addition to R&D projects, IGDAS participates in some projects that aim to increase the quality of equipments used in network. IGDAS's managers stated that the main aim is to decrease operation and maintenance costs of distribution network; therefore, they are planning to allocate more resources for R&D projects in the coming years. In addition, they stated that R&D intensity has increased since liberalization, and NGML has positive effects on R&D expenditures of IGDAS.

Contrary to R&D expenditures, all 17 distribution companies have made innovations which are shown in Table 2. Although the number of innovations differ among companies, all companies have made at least one type of innovation. The first type of innovation is related with product and process innovations. Distribution companies have enabled on-line customer services which enabled customer to reach information about their bills, consumption figures, etc. Moreover, some distribution companies started to inform customers via e-mails or cell phone messages. In addition, project application can be made and tracked via internet in some distribution companies' websites. The second type of innovation is related with marketing. Some distribution companies used new methods (such as mobile pay desks, or subscription at door) for customer subscriptions and bill payments. In addition, most distribution companies initiated marketing campaigns to attract more customers. The third type of innovation is related with organizational innovations. As in the case of electricity, organizational innovations have been a priority for distribution companies and nearly all distribution companies have made innovations to enhance their IT system and improve their technical infrastructure. Another organizational innovation is the establishment of intra-firm vocational training systems and use of new management methods to improve efficiency and effectiveness. In line with the use of new management systems, some distribution companies obtained international quality management system certificates such as ISO 9001, ISO 14001 and OHSAS 18001. Apart from intra-firm innovations, some distribution companies initiated customer-education programs in cooperation with government agencies.

Considering the R&D expenditures and innovations made by natural gas transmission and distribution companies, it can be said that establishment of a competitive and liberalized natural gas market resulted in major organizational innovations and some product/process and marketing innovations in Turkey as witnessed in other countries. On the other hand, the impact of liberalization on the R&D expenditures of natural gas transmission and distribution companies is unclear in Turkey. Among the distribution companies, only one enterprise is performing R&D expenditures, and R&D intensity of that company has increased since liberalization. Why other distribution companies have refrained from performing R&D expenditures can be answered by looking at three major reasons. The first major reason is the application of fixed distribution margin for new distribution companies for the first eight years of their license acquisition. According to NGML and secondary legislation, the distribution margin is fixed for the first eight years, and distribution companies cannot charge any other payment except for the distribution margin and connection fee (which is also determined by EMRA) from customers. In addition, some distribution tenders resulted in very low distribution margins. Therefore, distribution companies are expected to refrain from unnecessary expenditures in order to prevent extra costs in the first eight years, and some officers stated that they have not performed R&D expenditures as a result of fixed distribution margins. In addition, five-year constraint on firms to connect economically and technically feasible customers (although there has not been any definition of economically and technically feasible customer in NGML or secondary legislation) to network force firms to finish intrastructure investments as soon as possible, and this constraint may be another reason for the lack of R&D expenditures. The second major reason is the uncertainties regarding the status of BOTAS and the privatization old distribution companies. After the enactment of NGML, five previous distribution companies were privatized and privatization of one company is continuing, and only IGDAS will not be privatized. The officers of these distribution companies stated that they were mostly involved in the restructuring of the companies after privatization, therefore, they did not perform any R&D expenditures to prevent extra costs. Considering that only IGDAS which has established most of its distribution network before the enactment NGML, has been performing R&D expenditures, it can be expected that distribution companies' R&D expenditures may increase after they have completed infrastructure investments. The third major reason is the insufficient incentives and costs of R&D projects and innovation. As witnessed in other countries, distribution companies refrain from R&D expenditures because of uncertainties related with market, increasing risks and profit concerns. Some officers stated that it is less costly to acquire new equipments from abroad rather than participating in R&D projects. Therefore, more incentives should be provided to transmission and distribution companies to increase R&D expenditures and innovative activities.

5. Conclusion

Innovation and R&D are essential to create sustainable and renewable energy technologies and to decrease the adverse effects of energy production and consumption patterns on environment. On the other hand, besides the problems intrinsic to innovation and R&D in energy sector, energy market reforms are considered to affect both public and private energy R&D expenditures adversely and lead to customer-oriented innovations. Therefore, there are growing concerns about the transformation to a sustainable and low-carbon energy production and consumption patterns.

In this article, the impact of energy market reforms on R&D expenditures and innovation in Turkey is assessed. Experiences of other countries show that these reforms had adverse effects on the type and time-span of R&D expenditures and shifted innovations

from product innovations to marketing or organizational innovations. Turkey has also witnessed a decrease in government energy R&D expenditures as a share of GDP and a decrease in business sector real EGWS expenditures. Moreover, both electricity and natural gas transmission companies have not made any R&D expenditures since 2001. Similar to these companies, nearly all of the electricity and natural gas distribution companies have not performed any R&D expenditures. On the other hand, all companies have made innovations and most of these innovations are related with organizational innovations.

However, the impact of energy market reforms on innovations and R&D expenditures is not so apparent in Turkey. Because, Turkey has not completed its transition to competitive and liberalized electricity and natural gas markets, privatization of some distribution companies have not been completed and there are legal uncertainties regarding the status of state-owned companies. Moreover, insufficient incentives, lack of collaboration among enterprises, universities and government agencies and other problems create major obstacles for innovation and R&D in Turkey. Therefore, energy market reforms may have a positive effects on innovation and R&D expenditures as Turkey overcomes these problems.

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